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Nitzky,
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RESTORATIVE EFFECTS OF AIR IONIZATION IN NATURAL SETTINGS: FINAL REPORT FOR AIR IONS: PHASE II

by
Alene Nitzky

Final Report
for
AIR IONS: PHASE II

Restorative Effects of Air Ionization in Natural Settings

by
Alene Nitzky
Department of Recreation Resources
Colorado State University

Submitted to
Dr. B.L. Driver
USDA Forest Service
Rocky Mountain Forest and Range Experiment Station
240 W. Prospect
Fort Collins, CO 80525

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THE ROLE OF NATURAL SETTINGS IN REDUCING IMMEDIATE NEGATIVE CONSEQUENCES OF STRESSFUL EVENTS[1]

by

Alene Nitzky, Doctoral Candidate
Department of Recreation Resources
Colorado State University

B.L. Driver, Research Social Scientist
USDA Forest Service's
Rocky Mountain Forest and
Range Experiment Station

and

Glenn Haas
Department of Recreation Resources
Colorado State University

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THE ROLE OF NATURAL SETTINGS IN REDUCING IMMEDIATE NEGATIVE CONSEQUENCES OF STRESSFUL EVENTS

ABSTRACT

This study investigated effects of negative ions while subjects watched videotapes of natural and urban water-proximal settings after viewing a stressful film. No effects of ions were observed in any of the dependent measures of heart rate, pulse volume, or mood. Self-reported positive affect decreased in all groups, but natural setting groups experienced significantly less reduction in positive affect than urban groups during the setting videos. Results suggest visits to natural settings help to a greater extent than urban settings in minimizing the reduction in feelings of well-being and associated negative consequences immediately following stressful events.

Keywords: negative ions, psychophysiological measures, stress

Introduction and Background

For some time, researchers and leisure professionals have been working to understand and quantify the benefits people derive from the use of amenity resource-based goods and services, including recreation on public lands. Information is needed on the benefits of forest land management and on better methods of measuring those benefits (Driver, 1992). A benefit is defined as an improvement in condition or gain to an individual or group of individuals (e.g. families, communities, or society), or prevention of a worse condition through some maintenance function (Driver & Peterson, 1987). Benefits research seeks to identify ways in which individuals and larger groups of people within society improve or maintain their quality of life through the use of amenities such as recreation, and to measure the extent and magnitude to which beneficial consequences are derived by these different user groups (Driver, 1992).

As knowledge is gained about the benefits of amenity resource use and these benefits are quantified, agencies will be able to build a stronger case for political support in obtaining funding for preserving and managing these areas (Ulrich, 1988). Recreation settings with unique features, especially those shown to have beneficial consequences for users of these areas, may be more highly valued by decision-makers. Understanding the relationships between preferences for different recreational settings and experiences and certain indicators of physical and mental health and well-being is an important area of need. This includes understanding how features of certain natural and urban settings (e.g. high negative ion concentrations in water-proximal areas) may act on human physiological systems and behavior to influence health and well-being.

Quantifying the health benefits of visiting parks and natural areas is another important and timely need. Solutions are needed now for political decisions regarding the future of public health in the face of increasing expenditures for health care (Godbey, 1991). Mental health effects associated with stress have been well-documented and the cost of physical ailments linked to psychological distress is estimated at up to $100 billion annually (Sauter, Murphy & Harrell, 1990). Individuals will be able to use knowledge about the benefits associated with these amenity resources to make informed choices when deciding how and where to best utilize leisure time, and will be better able to obtain such benefits as improved health, lower medical bills, and improved financial security. Families, communities, and

society will benefit from subsequent benefits such as a stronger economy (Lee & Driver, 1992) and savings in health care expenditures (O'Donnell & Harris, 1994). Information from studies which address these needs contributes to the research program on beneficial consequences of leisure now underway at the USDA Forest Service's Rocky Mountain Forest and Range Experiment Station.

The present study addressed the research need of identifying psychological and physiological health benefits associated with certain recreational settings. Water-proximal areas are often highly preferred by recreationists (Clark & Downing, 1984), and some of these areas may have high concentrations of negative air ions (Coppom, 1978). Negative ions have been demonstrated empirically to have beneficial physical and mental health effects (Yates, et al., 1986), and have been found in outdoor settings which are amenable to leisure opportunities (Krueger & Sigel, 1978; Nitzky & Driver, 1994; Reiter, 1985). The benefits associated with negative ions in these recreational settings were the focus of this study, where negative ionization was hypothesized to provide physical and mental health benefits when it is encountered in these settings near water, where it may occur in high enough concentrations. The beneficial consequences of exposure to negative air ions may be one of the outcomes people seek when they preferentially visit places with water as a dominant feature.

The present study addressed several questions identified by the needs for research on benefits of leisure. The purpose of this study was to determine whether there are beneficial health consequences of exposure to different concentrations of negative air ions as encountered during recreational activities in water-proximal natural and urban settings, using a psychophysiological approach to measurement. This psychophysiological approach combined verbal and nonverbal measures to quantify restorative responses to videotapes of natural and urban settings at different concentrations of negative air ions. The following questions were addressed here:

1. What, if any, are the psychophysiological effects of exposure to naturally-occurring concentrations of air ions as encountered in natural and urban recreation settings?
2. What concentrations of negative ions are necessary to produce any of these effects?
3. If any effects are found at low concentrations of negative ions, what is the magnitude of

psychophysiological change with short-term exposure to these conditions?
4. Are certain types of settings (i.e. natural or urban) with negative air ions more conducive to recovery from short-term stress than others?

The following section reviews two areas of research: the restorative effects of natural environments and their stress-reducing influences, and the effects of negative air ionization, both of which are relevant to the present study.

Restorative environments and stress recovery

The idea that natural environments provide restorative benefits for people is found in scientific and anecdotal writings and has been the basis for advocating preservation of wilderness, forests, open space in urban areas, and parks. This movement started long before a sizable body of evidence existed to show that these areas are beneficial (e.g. Olmsted, 1865). Physicians and scientists have cited the importance of natural areas in promoting peacefulness and providing restorative influences (Driver & Greene, 1977; Stainbrook, 1968). The different perspectives on why people tend to feel better in natural rather than urban areas are known as psychoevolutionary perspectives. According to these views, people prefer natural or restorative environments over urban areas because humans evolved in natural settings. Places where food and water might have been available to primitive humans to provide for basic physiological needs would be most preferred, especially places with water and vegetation (Ulrich, 1983). The fundamental premise behind the concept of restorative environments is that humans evolved in natural settings over millions of years, and the fast-paced, built environments and urban life in which most modern humans now live has only existed as we know it for the past century. As a result, our bodies and brains are still tuned for natural settings, not having evolved adequate means of adapting, so we still need frequent contact with nature to cope with the stresses of modern life (Driver & Greene, 1977; Dubos, 1976; Stainbrook, 1968; Wohlwill, 1983).

These restorative environments may provide positive influences on health and well-being as a consequence of visitation, and may improve an individual's physical and/or psychological state from a worse to a better condition. These improvements can be measured verbally or nonverbally and may be characterized by such changes as improved mood, gains in cognitive performance, reduced blood pressure, decreased adrenal

corticosteroid release, improved immune response, and others (Ulrich, 1988; Ulrich, Dimberg, & Driver, 1991).

The addition of vegetation to urban settings has been shown to improve subjects' self-reports of positive affect and improved perception of quality of life (Sheets & Manzer, 1991). Both positive and negative affective states may be affected by visits to natural areas near cities (More & Payne, 1978). Subjects exposed to natural scenes have also demonstrated greater recovery from stress than subjects exposed to urban scenes (Ulrich & Simons, 1986; Ulrich, et al., 1991). The present study attempted to simulate natural conditions of air ionization with an ion generator and videotapes of different settings. Natural scenes and urban scenes have been used in many studies of preferences for environmental content. There is evidence of validity of simulating natural environments with sound in laboratory experiments (Zube, Vining, Law, & Bechtel, 1985) and for color-sound videotapes in experiments using psychophysiological approaches to measurement (Ulrich, et al., 1991).

There have been a number of studies which address these preferences for water and vegetation, and there is now considerable evidence that people do prefer natural settings and scenery with this type of content, especially water-proximal areas (Clark & Downing, 1984). Water-proximal natural and urban settings may contain naturally elevated concentrations of negative air ions (Coppom, 1978). Negative air ions have been shown to have many positive effects on health and well-being (Yates, Gray, Misiaszek, & Wolman; 1986). In the present study, negative air ions were proposed as an influence on some of these restorative responses to different natural and urban water-proximal settings. Empirical findings have shown that water enhances scenic quality of landscapes (Zube, Pitt, & Anderson, 1975), and scenes with water features often receive high ratings in studies of scenic preferences (Brush & Shafer, 1975; Brush & Palmer, 1979). Mountain waterscapes, especially with rushing water, were most highly preferred in a study of preference for different types of waterscapes (Herzog, 1985). Water is an important consideration is recreationists' choices of where to engage in recreational outings (Clark & Downing, 1984; Lime, 1971; Lucas, 1964), and the "magical" and "rejuvenating" properties of water have been described by some authors (Ryback & Yaw, 1976).

Reduction of mental fatigue is an important restorative effect of natural settings, which allow a type of mental escape following prolonged periods of concentration (Kaplan & Kaplan, 1989). The concept of escape has also emerged in recreation research. Driver and colleagues work on motivations for outdoor recreation experiences revealed that escape was an important outcome sought by recreationists (Driver & Cooksey, 1980; Driver & Knopf, 1976). Recreation experiences, even when perceived in artificial settings, have been demonstrated to provide relief from tension and stress (Heywood, 1978). It has been suggested elsewhere that humans may have an innate tendency to respond favorably to natural settings with water and vegetative content (Ryback & Yaw, 1976; Stainbrook, 1968).

Stress is a perceived threat or anticipation of future harm (Lazarus, 1966). A stressor is a stimulus or event which is perceived to exceed or tax one's resources and interfere with well-being (Frijda, 1986). Short term or acute stress is caused by events which may have powerful and sudden impact, but are usually not prolonged and may be outside of individual control, such as natural disasters, illness, or divorce (Lazarus & Cohen, 1977). Acute stress can be induced by showing of stressful films, mental arithmetic, noise, distractions (Lazarus & Cohen, 1977). Films which have been demonstrated to be valid stressors have been used in numerous experiments as an effective means of inducing short-term stress (Goleman & Schwartz, 1976; Lazarus, Opton, Nomikos & Rankin, 1965; Ulrich, et al., 1991). Long-term or chronic stressors are often not dramatic events, but are repetitive and persist over longer time periods, such as noise (Glass & Singer, 1972) or "daily hassles" (Lazarus & Cohen, 1977, p. 92), and usually require some type of coping responses (Campbell, 1983). Physiological factors influencing stress response may impact the immune system (e.g. release of corticosteroids and norepinephrine) (Frijda, 1986), including reduction of the body's defenses against cancer (Parrillo & Fauci, 1979) and cardiovascular disease (Dembroski & Costa, 1987). In the present study, leisure activities in restorative environments were proposed as a means of coping with stressors.

Psychophysiological measurement of stress recovery

The psychophysiological approach employs measures of physiological activity related to human behavior (Ulrich, 1988). This approach to measurement is ideal for assessing

response to stress recovery (Ulrich, Dimberg, & Driver, 1991). Ulrich has used this approach extensively to measure recovery from different types of stressors (Ulrich, 1981, 1984; Ulrich & Simons, 1986; Ulrich, et al., 1991). Some indicators of improvements in physiological state are heart rate, decreased blood pressure, decreased skin conductance response, reduced muscle tension, decreased release of adrenal corticosteroids, improved immune response (Maddi, Bartone, & Puccetti, 1987; Ulrich, Dimberg, & Driver, 1991). Verbal measures may include self-reports of different dimensions of mood (Hull, 1991). Studies utilizing combinations of verbal and non-verbal measures of response to environmental stimuli, including consequences of experiences from the use of amenity resources are strong from a validity standpoint and are ideal for measuring response to environmental stressors. Psychophysiological measurement approaches combine both of these types of measures. Verbal measures include questionnaires and self-report instruments which assess psychological state (e.g., mood). Nonverbal measures may include both behavioral (e.g. cognitive processing, attention task performance) and physiological (e.g. heart rate, muscle tension) indicators of functions in different body systems. Combining verbal and nonverbal measures may yield greater convergent validity of results, providing more credible data (Ulrich, 1988; Ulrich, Dimberg, & Driver, 1991).

Physiological data is highly regarded by courts and the medical profession, especially in making political decisions, including environmental impact statements (Ulrich, 1988; Ulrich, Dimberg, & Driver, 1991). In the present study, verbal measures of positive and negative affect were combined with nonverbal measures of autonomic responses to measure restorative response to negative air ionization in different settings. This study looked at cardiovascular measures which can be observed with non-invasive procedures. Measures of autonomic nervous system activity can be made by monitoring cardiovascular activity with measures of heart rate and blood pressure, as the cardiovascular system is innervated by the autonomic nervous system. Measures of autonomic activity have been demonstrated to correspond to positive and negative emotions (Ekman, Levenson, & Friesen, 1983). Heart rate response can be measured by simple pulse-measured in beats per minute. Heart rate accelerates with mental concentration, excitement, boredom, and performance of delicate motor tasks, and decelerates with intense concentration on visual and auditory stimuli.

Changes in heart rate tend to be related to intensity of stimuli. The purpose of heart rate changes are to adjust the oxygen supply to the brain and the muscles.

Blood pressure can be measured with a sphygmomanometer and cuff instrument. It increases with noise, mental concentration, anger, and stress, and decreases with relaxation. Blood pressure returns to normal after the stressful situation, but over prolonged periods of stress it may adapt to higher levels, in some cases leading to the development of hypertension (Frijda, 1986). One drawback of measuring blood pressure by ordinary methods is that some people may find this method intrusive, and blood pressure may rise as a result of taking the measurement. Another cardiovascular measure which is highly correlated with blood pressure is pulse volume, which can be measured with a device called a photoplethysmograph. This device uses a photocell as a transducer to convert light into electrical energy. These readings convey information about beat-to-beat changes in blood flow, and are useful for studying relative changes in in blood flow. This method is useful for non-invasive measures of peripheral blood flow. Increases in pulse volume would indicate dilated vessels and generally healthier states than decreased pulse volume (Caccioppo & Tassinary, 1990).

Measures of mood: PANAS scales. Mood is an important indicator of response to environmental stimuli which may have long-term consequences on health and the immune system. Mood consists of cognitive (self-awareness of mood state), behavioral (communication of feeling, e.g. facial expression), and physiological (level of arousal) components (Hull, 1991). Short-term effects of mood are evident in autonomic, neuroendocrine, skeletomuscular, and immune responses, and over long periods of time mood may influence immune response (Stone, Cox, & Valdimarsdottir, 1987). An instrument for verbal assessment of positive and negative affect response is the Positive Affect and Negative Affect Scales (PANAS) (Watson, Clark, & Tellegen, 1988). These scales have the ability to measure levels of both positive affect (PA) and negative affect (NA) in different time frames and provide a reliable and valid mood profile when given under different time frame instructions. These brief scales were developed based on knowledge of the two primary dimensions of mood which are consistent across studies of affect (Bradburn, 1969; Russell, 1980; Watson, et al., 1988; Watson & Tellegen, 1985; Zevon & Tellegen, 1982). These two dimensions have emerged as independent factors rather than opposite

dimensions in factor analyses of affect (Watson, et al., 1988).

Positive affect (PA) is related to social activity and satisfaction and to the frequency of pleasant events, while NA is related to frequency of unpleasant events, health complaints, self-reported stress and poor coping (Clark & Watson, 1988). NA is correlated with perceived stress and shows no diurnal pattern, while PA is related to social activity and shows diurnal variation, rising in the morning while remaining stable throughout the afternoon, and declining in the evening. When used with short-term instructions both scales are sensitive to fluctuations in mood. They have displayed evidence of reliability and validity for repeated use over short periods of time and can discriminate between positive and negative affect (Cronbach's alpha =.89 (PA) and .85 (NA) with momentary mood instructions) (Watson, et al., 1988). Mood may also be influenced by negative air ion exposure. High concentrations of negative ions have been linked to improved mood (Hawkins, 1981; Tom, et al., 1981). The following section will review the literature on air ionization and its effects on human physiology and behavior.

Air ionization

Air ions are electrically charged atmospheric gas molecules produced by natural physical forces. When sufficient energy acts on gas molecules to displace electrons, positive ions are formed. By the same process, the freed electrons may collide with other gas molecules to impart a negative charge, forming negative ions (Hedge & Eleftherakis, 1982). These common atmospheric gases are usually forms of hydrogen, oxygen, water vapor, or carbon superoxide compounds (Hawkins, 1981; Rosenthal & Ben-Hur, 1980). Some common physical forces which may produce air ions are radiation, electromagnetic waves (Hedge & Eleftherakis, 1982), wind shear associated with the movement of large volumes of air over land (Krueger & Reed, 1976), and shearing of water droplets in turbulent water (e.g. rapids, waterfalls) (Krueger & Sigel, 1978). Recent studies of health and behavioral effects of negative ionization have also yielded convincing evidence that negative ions may provide beneficial consequences under lower concentrations, such as those found naturally in some water-proximal areas. In the present study, negative ions were artificially generated at levels found naturally in outdoor settings and used to test physiological and psychological effects of exposure to these ions. It follows that if negative ions provide beneficial health

effects at levels which are found outdoors in certain natural and urban settings, then health benefits of ionization could be realized by recreationists engaged in activities in these highly ionized areas. Hundreds of studies of positive and negative ion effects on living organisms have been conducted, and while results have sometimes been conflicting and inconsistent, the general pattern of findings seems to indicate that in high concentrations, negative ions tend to have positive effects on humans and animals, while positive ions tend to have negative effects (Soyka & Edmonds, 1978; Yates, et al., 1986).

Serotonin hypothesis of air ion action. Krueger, Andriese, and Kotaka (1963) developed what is known as the serotonin hypothesis of air ion action based on their findings over many years of research. Serotonin is a neurotransmitter involved in mood, sleep, arousal, and other functions, and is found in the brain and body tissues (Carlson, 1991). Their theory says that positive ions accelerate the release of serotonin from body tissues and the brain; while negative ions accelerate it's rate of oxidation (the rate at which serotonin is broken down and excreted) (Krueger, et al., 1963). The serotonin hypothesis currently stands as an explanation for the effects of air ions on humans and mammals. In recent years, few studies have been conducted to confirm or disconfirm this theory.

Negative ions have been used in psychiatric hospitals and have been found to relieve some symptoms of depression and anxiety disorders (Deleanu & Stamatiu, 1985). Office workers suffering from headaches and nausea experienced significant relief when negative ions were introduced to their ion-depleted office environment, and alertness in night shift workers was significantly increased with exposure to negative air ions (Hawkins, 1981). Negative ions have been linked to increases in arousal which may account for this increase in alertness, possibly through actions on serotonin metabolism. Interpersonal attraction was found to increase under exposure to negative ions (Baron, 1987b), and increased aggression was demonstrated under conditions of negative ion exposure, with a curvilinear relationship between the concentration of negative ions and level of aggression (Baron, Russell, & Arms, 1985), similar to the Yerkes-Dodson inverted-U relationship between arousal and aggression (Yerkes & Dodson, 1908). Air ions may influence systolic and diastolic blood pressure, which are under autonomic nervous system control. Baron (1987a) reported small but significant increases in both mean systolic and diastolic blood pressure under 10^4 ions/cm^3

exposure, but found no significant change in either pressure at 10^2 ions/cm^3. In the same study, no change in resting heart rate was found as a result of air ion exposure at either of these two levels.

Reiter (1985) recorded concentrations of positive and negative small air ions over a five year period at two locations in Germany and found similar numbers which agreed with earlier reports (Hawkins, 1981), and found that meteorological conditions influence air ion concentrations, but failed to find dramatic shifts in ionization previously attributed to regional winds. The presence of turbulent water (e.g. waterfalls, river rapids) may increase the negative air ion concentration to where the positive to negative ion ratio is 0.1:1 in close proximity to the rushing water (Nitzky & Driver, 1994). Nitzky and Driver found air ion conditions consistent with earlier reports (Table 1) under similar urban and natural conditions (Hawkins, 1981; Krueger & Sigel, 1978; Reiter, 1985), and found negative ion concentrations within 25 feet of highly turbulent water to reach approximately 5 x 10^3 ions/cm^3. These high natural negative ion concentrations have also been found in pine or fir forests, on beaches with surf, and after thunderstorms (Coppom, 1978).

Air ion concentrations in most studies were generated artificially and did not represent concentrations encountered naturally under everyday conditions. High concentrations in the order of 10^5 ions/cm^3 and higher might have been unrealistic, as no reports of natural indoor or outdoor concentrations of ions have exceeded this number (Charry, 1984; Hawkins, 1981; Nitzky & Driver, 1994; Reiter, 1985). Older models of air ion generators produced some ozone and nitric oxide, two compounds which also produce biological effects and may have accounted for some of the effects seen in these studies (Charry, 1984; Kroling, 1985; Nogrady & Furnass, 1983). There is evidence that effects of negative air ionization can be observed at lower concentrations, in the range of 10^2 to 10^3 ions/cm^3. Negative ion concentrations outdoors in water-proximal settings near turbulent bodies of water have been found in this range (Nitzky & Driver, 1994), so it appears that effects of negative air ionization may be observed either outdoors in these natural environments, or indoors in a laboratory setting where realistic levels of ionization can be generated artificially.

Theoretical Framework

The model tested in this study explains the effects of negative ionization in natural and urban settings on physiological and psychological responses that lead to short-term benefits. In the model, a person's psychophysiological state while engaged in a recreational activity is influenced by two factors, the type of setting and the ambient level of negative ionization. Via the physiological mechanisms by which air ions work (e.g. serotonin or other mechanisms) and associated psychological responses, these two factors will influence subsequent psychophysiological states which are associated with a certain degree of stress recovery. During the recreational engagement, the person experiences changes in his or her health state, and improvements in health are immediate beneficial consequences. A person in a highly negative-ionized setting experiences more beneficial consequences than a person exposed to lower levels of negative air ions, and also experiences more benefit from natural settings than urban settings across all concentrations of air ions.

Purpose of Study

The purpose of this study was to determine whether high concentrations of negative ions, as might be encountered in urban and natural water-proximal settings during recreational activities, have restorative mental and physical health influences following short-term stressful experiences, as measured by psychophysiological indicators of stress recovery. Using a psychophysiological approach, verbal and nonverbal indicators of stress recovery (positive and negative affect, heart rate, and pulse volume) were measured under different conditions of negative ion exposure and videotape-simulated natural and urban outdoor settings. Data from these indicators of stress recovery were examined for evidence of restorative responses to negative air ionization which could have beneficial consequences for people engaged in recreational activities in these types of settings.

Hypotheses

The following hypotheses were tested in the present study:

1. Higher concentrations of negative ions will produce greater recovery from a short-term stressor than lower concentrations of ions, as indicated by the following psychophysiological responses:

a. decreased heart rate
b. increased pulse volume
c. increased positive affect
d. decreased negative affect

2. Natural settings on videotape will produce greater recovery (indicated by a-d above) from a short-term stressor than urban settings on videotape across different concentrations of negative ions.

Methods

One hundred male and female subjects, 18 to 51 years of age volunteered to participate in the study. Subjects were undergraduate and graduate students enrolled in courses in the Department of Recreation Resources at Colorado State University during the 1993-94 school year. Subjects were randomly assigned to treatment groups prior to the commencement of data collection. All subjects provided their informed consent to particpate.

All measurements were conducted in the Center for Biomedical Research in Music at Colorado State University. A general questionnaire was administered prior to subject participation to assess each subject's general health. Information about the subject's background was collected (age, gender, medications currently taken, any problems which might interfere with data collection, e.g., severe asthma, broken bones, visual impairment, inability to watch a stressful film). This health information was used to screen subjects for further participation. Subjects were asked about caffeine, alcohol, or nicotine consumption in the 12 hours before the experiment, strenuous activity immediately prior to the session, or any behavior that might affect responses during the experiment. All subjects wore cotton or wool shirts and socks during the experiment.

In the laboratory room, the windows were covered with curtains made from a light-blocking fabric. All edges of the window frame were sealed with tape to eliminate daylight from the room. During the experimental session, the only light used in the lab was a 500 watt halogen lamp, which provides full spectrum light similar to natural outdoor lighting (Thumann, 1992). This procedure allowed the amount of light in the lab to be kept uniform across day and night sessions and different outdoor weather conditions. All visual stimuli were removed from the walls of the room and the subject's chair was turned away from the

investigator's desk and equipment to reduce distractions. Only the video monitor and a blank wall were visible to the subject while seated in the chair.

Experimental treatments

Negative air ions. Negative air ion concentrations in the lab were continuously monitored using a Model Beckett Air Ion Counter and Mobility Discriminator (American Environmental Systems, 1987), which was connected to a Keithley Model 616 electrometer which gave continuous readings of ion concentrations. Ion levels in the laboratory room were controlled with a Alpine Air Purifier negative ion generator (ComAir Corporation, 1993). Ion concentrations for the different treatments were maintained at low (0-400 ions/cm^3), moderate (750-1500 ions/cm^3), and high ($6 \times 10^3 \pm 10^3$ ions/cm^3) concentrations, respectively. All subjects were connected to an electrical ground according to standard procedure (Charry & Hawkinshire, 1976) with a metal ground plate attached to the wrist and connected to an electrically grounded location on the equipment. Subjects wore cotton shirts and socks to avoid the buildup of positive or negative electrical potential, which would interfere with ion exposure (J.E. Yehl, personal communication, July 9, 1991). The ion counter and ion generator were located in an inconspicuous location to divert attention from their presence. The ion counter was positioned beside the subject's head (2 feet/0.6 m away) to measure the ions in the vicinity of the subject's face periodically during the experimental procedures in order to maintain sufficient concentrations of inspired air ions. Measuring air ions before and after the experiment in this manner has been demonstrated to reliably measure the concentration of inspired ions (Frey, 1965). Air ion concentrations were maintained at the respective treatment levels throughout the recovery period.

Settings. Subjects were exposed to one of two water-proximal settings on videotape, either a natural or an urban scene, preceded by a set of written instructions appearing on the screen for 30 seconds at the beginning of the video. The natural setting was an 18 minute video featuring a riverbank in the foreground with turbulent water flowing by in the river in the middleground, and scenic cliffs and trees in the background. The rushing water was audible and was the dominant sound on the videotape. The urban setting was an 18 minute video of a walking path adjacent to a river running through a downtown urban area. The foreground contained the walkway and the river with the middleground and background

dominated by sidewalks and buildings. The setting contained little traffic or excessive visual and auditory stimuli to avoid provoking emotional reactions to the scene.

The experimental session consisted of three distinct time periods (baseline, stressor, and recovery) for purposes of data collection. The first was a three minute baseline period where recordings of heart rate and pulse volume were taken to determine the subject's initial physiological state. The Positive Affect and Negative Affect Scales (PANAS) (Watson, et al., 1988) were administered to each subject three times through the duration of the experiment, at the beginning of the baseline period, immediately after the stressor film, and again after the video scene (recovery period). The PANAS is a brief adjective checklist with instructions pertaining to how the subject feels at the present moment. At the beginning of the baseline period the first PANAS was also administered to assess the subject's initial affective state. Baseline dependent measurements were recorded for each subject prior to the start of the stressor film with which to compare later physiological responses throughout the experiment. Immediately following baseline, there was a twelve minute stressor period during which the stressor film was shown. All subjects were exposed to a 12 minute stress-inducing film of a woodshop accident "It Didn't Have To Happen", which has been used in previous studies and has been shown to be an effective and valid short-term stressor (Goleman & Schwartz, 1976; Lazarus, et al., 1965). Following the stressor period, there was an 18 minute recovery period during which a setting video was shown and the negative air ion exposure occurred. The experimental session for each subject consisted of 33 minutes of procedures.Measures of heart rate, skin conductance, and pulse volume were monitored by the investigator continuously throughout the three time periods using the Biolab computerized monitoring system (Autogenic Systems, 1990) and were recorded directly onto an IBM personal computer.

Procedure

Upon arriving at the lab, each individual subject was met by the investigator, led into the lab, and asked to sit in a chair while the procedures were explained. After all questions were answered, the subject was asked to read and sign a consent form, followed by a questionnaire assessing behavior prior to the experiment, and the first of three mood questionnaires (PANAS). The subject was then asked to remove shoes and any jewelry on the

non-dominant hand, and to wash their hands at the sink with mild soap and water.

The electrical ground plate was applied to the wrist of the non-dominant hand with a small amount of Redux electrode creme, and the sensors were applied to the fingers of this hand. The purpose of the electrical ground was explained and each subject was assured that it was for safety to avoid electric shock. As the sensors were attached, the investigator explained the purpose of each one and answered any questions. The photoplethysmographic sensor for measuring pulse volume and heart rate was applied after the middle finger was cleaned with alcohol. The investigator performed a brief wrist palpation to check the accuracy of the machine's light indicator to ensure that the heart rate was being recorded accurately. The two skin conductance sensors were applied to the index and third fingers, and the subject's hand was placed with the palm facing up on the armrest of the chair. The subject was asked to find a comfortable position sitting in the chair with feet on the floor, and was reminded to avoid talking and movement during the recording periods. They were asked to ask questions or reposition themselves if necessary only in between the three time periods when the recordings were stopped for the subject to fill out the PANAS. It was explained that this was to avoid movement artifact.

When the subject was prepared, the investigator started the computerized system for the baseline period of 3 minutes, following which the subject was asked if he or she was ready to start the next part of the experiment. It was explained that the film might contain a few unpleasant scenes. The film was started and recordings were resumed until the end of the twelve minute stressor film, when the subject was asked to fill out the second of the three PANAS scales. Following this, subjects were asked to relax for the second video and to imagine they were in the location shown while avoiding any distracting thoughts. The setting video was started and recordings were resumed at the end of the video instructions while the ion generator was switched on. At the end of the 18 minute video, the subject was asked to fill out the last PANAS, and during that time the investigator took a final measurement of air ions. The investigator then removed the sensors and cleaned the electrode paste off the subject's wrist, and the subject was free to go. After the subject left the room, a final ion measurement was made, and the room was ventilated with fresh air from the windows to allow the ion concentration to return to the low level (<400 ions/cm^3).

Data Collection, Analysis, and Reduction

Data were collected during the 9 week period from November 30, 1993 through February 1, 1994. Positive and negative affect measures were obtained for three different periods: baseline, stressor, and recovery. Recordings of negative ion concentrations were made 7 times within each session and monitored continuously to ensure that ion exposure stayed uniform throughout the recovery period. Heart rate and pulse volume were continuously recorded every second during the 33 minutes of procedures.

Data analysis was performed using SPSS-PC Version 5.0 (Norusis, 1992), and a significance level of $p=.05$ was used to test all hypotheses. Two-factor analysis of covariance was used to analyze the effects of ionization and video settings. The differences between each subject's baseline and stressor measures for each dependent variable were used as covariates when regressions between these and subsequent recovery measures were significant. Regression relationships were homogeneous among ionization and setting factors in all cases. Since the baseline and stressor measures were all independent of the level of treatment (the only difference in group treatments was during the recovery period), and the amount of reaction or change from baseline during the stressor period (the amount of stress response induced by the film) was different for different people, one would expect nonuniform responses across the entire sample. Separate analyses of variance were performed on the model by gender. Correlations between the dependent measures were analyzed during the baseline, stressor, and recovery periods. All recovery period responses were plotted over time to look for differences in response pattern among the different treatment groups. Analyses of variance were performed for individual items on the PANAS to analyze changes over the recovery period.

In order to expedite the analysis of the resulting data set, it was necessary to reduce the data prior to analysis. For analysis purposes, the 3 minutes of baseline were combined and averaged together over the entire 3 minute period to give averages for heart rate and pulse volume. It was determined that minutes 3, 8, and 11 of the stressor period would be combined and averaged for a composite to be used as the stressor period score. These minutes correspond to the times of the stressor "onset" where the parts of film most likely to provoke a response from the viewer occurred. The last 3 full minutes of the recovery

period were averaged (minutes 15-17) to form a composite for the recovery period, since responses to ion exposure have taken up to 15 minutes observe in previous studies (Charry, 1984). Minute 18 was not used because of the abrupt end of the video during the last minute. Data from six of the subjects were rejected for error values. Of the remaining subjects, there were 50 males and 44 females, resulting in a sample of N=94.

Results and Discussion

Separate analyses of covariance were performed for each of the four dependent variables. There were no significant main or interaction effects among the negative ion treatments for any of the dependent variables. Therefore, hypothesis 1 was rejected for all the dependent measures (heart rate, pulse volume, and positive and negative affect). There were no significant main or interaction effects among settings for the dependent variables heart rate, pulse volume, or negative affect. All groups experienced a drop in self-reported positive affect, although there was a signifcantly greater decrease in positive affect among the groups who watched the urban setting video than in those who watched the natural setting (Table 2). None of the other analyses revealed any significant findings for negative ionization. Length of time of negative ion exposure did not affect responses differently over the duration of the recovery period in any of the treatment groups. In this study, subjects were exposed for 18 minutes to three different natural levels of negative ions. Since rigorous steps were taken to keep the level of ion exposure constant, it appears that the exposure time or the levels of ions were inadequate to produce a response. Past studies have used similar exposure times and slightly higher levels of negative ions and yielded positive results (e.g., Baron, 1987a, 1987b; Tom, et al., 1981) for responses to negative ions. Since grounding and measurement procedures were carefully followed here, it seems unlikely that instrumentation or experimenter error were a factor. Perhaps longer exposure times and/or higher doses of ions are required to produce responses in these dependent measures, or different dependent measures might indicate a response to negative ions under the present conditions. Exposure times of several hours or longer may be necessary to produce responses at these low levels of ionization. In order to further investigate the serotonin hypothesis, more invasive procedures may be necessary. Psychophysiological measures may not be sensitive enough to detect serotonin-mediated responses.

Hypothesis 2 was not rejected for the dependent measure of positive affect, although for heart rate, pulse volume, and negative affect, it was rejected. While there were significant differences in positive affect scores at the end of the recovery period between the natural and urban groups, both groups reported decreases in positive affect from the baseline to the recovery period. The natural setting group experienced significantly less decrease in positive affect over the recovery period than did the urban group. Although these results do not contradict previous findings that found natural settings have more restorative influence than urban settings (e.g. Hartig, Mang & Evans, 1991; Ulrich, 1981; Ulrich, et al., 1991), they do not show that there were restorative effects from the videotaped settings in this study. In both groups, positive affect continued to drop from the beginning to the end of the session, but the natural setting might have prevented affective states from dropping even lower than they did. Conceivably, a person undergoing a great deal of stress who then visits a natural area soon after the onset of the stressful event may sustain less of a reduction in positive affect and fewer related negative consequences than someone who visits an urban setting in the same time frame. Despite the significant findings of the test of hypothesis 2, inferences and interpretation of results are somewhat limited because there was no control group for the setting treatment. It would be difficult to simulate a control or "neutral" setting for this type of experiment since most environments normally encountered contain various types of sensory stimuli. Methods with which to address this problem are discussed in a later section.

Correlations Among Dependent Measures. Correlations among the dependent measures of positive affect, negative affect, pulse volume, and heart rate were performed for the three time periods of the experiment. For the baseline and recovery period, there were no significant correlations among dependent measures. In the stressor period, there were weak but significant correlations at the $p < .01$ level between heart rate and negative affect ($r = .31$), and between positive and negative affect ($r = .28$). Positive and negative affect are considered to be separate dimensions of affect and have been found to have low or nonsignificant correlations with each other (Watson, Clark & Tellegen, 1988). The stronger correlations during the stressor period are attributed to strong emotional response to the stressor film. Correlations between the two cardiovascular measures, heart rate and pulse

volume, were nonsignificant. Heart rate is an absolute measure in units of beats per minute while pulse volume is a relative measure indicating beat-to-beat variations in blood flow. Since minute-by-minute averages were obtained for purposes of data reduction, numbers may have been attenuated so that stronger correlations were concealed. The significant correlation between heart rate and negative affect in the stressor period could be a result of strong heart rate responses to stressor onsets in the film, while heart rate did not change dramatically at any time during the baseline or recovery periods.

Post-Hoc Procedures: Changes in dependent measures from pre- to post-recovery

Affective measures. Analyses of variance were run separately for individual items within the PANAS scales using the score difference between pre-recovery (stressor period PANAS) and post-recovery period as the dependent measure. For both positive and negative affect scales and individual items there were no significant differences in affect across the different ion treatment groups. There were significant differences between the natural and urban setting groups for several of the items and both the overall positive and negative affect scales (Table 3). In individual item scores, significant pre- to post-recovery differences were found between natural and urban setting treatment groups for the positive affect scale items "interested", "determined", and "inspired", and for the negative affect scale items "irritable" and "jittery". Detailed explanations of the contents of Table 3 follow in the next sections.

Positive affect items. The natural setting group showed a decrease in scores on the item "interested" by a magnitude of .45 points on a 5 point scale from the pre- to post-recovery period, while the urban setting group experienced a decrease of 1.06 points. Although both groups showed a decrease in scores on this item, the urban setting group reported a greater decrease in feelings of "interested". The natural setting group experienced an increase in the degree to which they reported feeling "inspired", while the urban setting group experienced no change from pre- to post-recovery on this item. The natural setting group experienced an increase in the degree to which they reported feeling "determined" from pre- to post-recovery while the urban group reported a decrease in feeling "determined".

Negative affect items. The natural setting group experienced a decrease in the degree to which they reported feeling "irritable" from pre- to post-recovery, while the urban group

experienced no change on this item. The natural setting group showed a decrease in the degree to which they reported feeling "jittery", while the urban group had a decrease in scores on this item to a lesser degree than the natural group.

Overall scales. PANAS score changes from baseline to recovery are reported in Table 4. The natural setting group experienced a decrease (1.76 points on a scale of 50) in positive affect from pre- to post-recovery, while the urban group reported an even greater decrease in positive affect (4.54 points). The natural setting group reported a greater decrease in negative affect (9.15 points on a scale of 50) from pre- to post-recovery than did the urban group (6.35 points). The natural and urban groups' reductions in positive affect from stressor to recovery were 1.76 and 4.54 points, respectively. Looking at the net change from baseline to stressor period, the decreases in positive affect were uniform, 4.59 and 4.61, respectively. By the end of the recovery period, the actual raw recovery period scores for positive affect were higher in the natural group than the urban group. Natural settings were associated with significantly lower decreases in positive affect than urban settings over the duration of the recovery period. Upon comparing the changes in certain items on the PANAS with the Ulrich, et al. (1991) findings using the ZIPERS (Zuckerman, 1977), the present results were opposite for similar items on the different scales. For the PANAS item "scared" there were no signifcant differences between natural and urban groups, and for the item "interested", the natural group had significantly higher scores than the urban group, while Ulrich, et al. reported signifcant findings with the item "fear" and non-significant findings with "attentiveness/interest". The Ulrich study also differed from the present study in that they used shorter recovery periods, about 9 minutes in length compared with 18 minutes in the present study.

Physiological measures. Upon examination of plots of the progression of heart rate and pulse volume throughout the recovery period, no differences were found in patterns of recovery across all treatment groups. Consequently, no further analyses were indicated for these recovery period dependent measures. Different segments of the recovery period were examined in post-hoc analyses because only the last 3 full minutes of the recovery period were used to analyze recovery period physiological responses in order to allow for 15 minutes of exposure to negative ions. Since studies of such low levels of ions have not been

reported before and exposure times have also varied in previous research, subjectively chosen equal time segments at the beginning and middle of the recovery period were used as response variables here. Omitting the first minute of the recovery period, minutes two through four were used as the beginning period. Minutes nine through eleven were chosen for the mid-recovery period.

Using early and middle segments of the 18 minute recovery period as dependent measures, analyses of variance were performed for heart rate and pulse volume. Using minutes two through four for early recovery period, and minutes nine through eleven for mid-recovery period, no differences from the original analysis were found in the results for either of the cardiovascular dependent measures. Consistent with the overall findings, naturally-occurring levels of negative ions did not produce physiological effects following these short exposure times. For all groups there was approximately a two beat per minute increase in heart rate from the beginning to the end of the recovery period. This response might have been a result of the subjects becoming bored with the setting videos, which varied little over the 18 minute recovery period. Boredom has been linked to increased heart rate (Frijda, 1986). The only apparent difference in recovery period responses among groups was that heart rate started and ended slightly higher in the two groups which received the moderate level of negative ions. These groups' initial and final recovery period heart rates were not significantly different from the other groups, but had they been significantly higher, there would have been a question of whether exposure to negative ions initially causes increased heart rate at those moderate levels.

Limitations of this Study

This study investigated psychophysiological responses to negative ion exposure in different types of outdoor recreational settings. Since the study was conducted in a laboratory setting, the results may not be generalizable to actual outdoor settings. It is impossible given the current state of technology to control for negative ion conditions outdoors since so many factors affect ionization. A similar experiment with 100 subjects conducted outdoors would be subject not only to a multitude of problems with lighting and climatic conditions, but would also be expensive because of the portable equipment required to measure physiological responses.

While this study measured indicators of recovery from acute stress, it is not known if the amount of acute or chronic stress being experienced by subjects at the time of their participation was uniform. For example, the timing of the experiment overlapped with several events which might contribute considerably to stress levels in a student population (final exam week, winter break, the start of a new semester, and holidays). Since this study was delimited to college students in natural resource majors, the sample may be different from the general population of people who visit these settings and might stand to benefit from them.

It was also assumed in this study that the videotapes of outdoor settings were adequate substitutes for places the subjects might visit for recreational engagements. While evidence exists to support the validity of using videotapes in place of real environments, it is not known whether this was a good assumption, as some students might have chosen different locations having been given a choice, and some might have become bored with the videos during the session. Finally, a quasi-experimental design was used with no control group for the types of settings, since a true experimental design would necessitate a control treatment that is unrealistic.

Another limitation of the study is the problem of the stressor film itself. The film is old and some subjects might have found it more amusing than stressful. Some subjects could be desensitized to violent scenes from television and media portrayal of violence and may not have found the film stressful by comparison. Longer exposure times might be needed to generate psychophysiological responses to negative ions, or perhaps there are outside variables which when combined with ions produce these responses. Since so many previous studies of negative ions had varied results, perhaps natural low levels of ions do not by themselves produce any responses. Given the number of studies which have found positive results, it is likely that some different combination of conditions (e.g., exposure time and level of ionization) may interact to produce the previously observed responses.

A final consideration which could restrict the inferences made from this study is a concern about the use of the PANAS scales. Although the PANAS shows evidence of high test-retest reliability in the "moment" time frame used in this study, there are potential shortcomings associated with administration of the same questionnaire three times within the

present study's hour-long experimental session. These problems may include response bias resulting from memory, practice, or carryover effects. Prior to analysis of the individual item responses from pre- to post-recovery, item-scale homogeneity was examined to see how highly correlated each of the item scores were with the overall scales. The item "interested" was the only one which was not highly correlated with the positive affect scale but did show a significant change from pre- to post-recovery.

Implications

This study addressed the previously stated research needs of understanding and quantifying benefits of amenity resource-based goods and services and their consequences. The findings of this study corroborate Ulrich's and others findings that natural settings are preferred over urban settings and visiting these natural settings may lead to significant short-term mental health benefits, which could then lead to long-term consequences in restoration or recovery from the stresses of everyday living. Future studies will be needed to quantify the benefits of short-term improvements in mental health and investigate links between these short-term improvements and long-term beneficial consequences. Increased awareness of the contribution of mental illness to health care expenditures could make this line of research more easily justifiable to decisionmakers. While the results of this particular study did not show restorative effects from natural settings, they also did not contradict previous findings that there may be beneficial mental health consequences (improved mood states) associated with stress recovery in natural areas.

In the present study, negative ions did not contribute to recovery from acute stress, although there may be features of natural settings other than negative ions that do contribute to restorative benefits. These features may be complex in nature, consisting of visual content, sounds, smells, or other characteristics of natural settings. Further research is needed to determine what features of natural settings might contribute to improvements in mental health. Research on preferences for water-proximal settings may provide insight into the features which make these settings desirable in both urban and natural areas and could help to quantify the magnitude of any contribution these settings make to overall health benefits. Based on the results of the present study, negative ions do not contribute to any

improvements in short-term health or well-being in these settings. Longer exposure to negative ions may be needed to produce these effects, but there could be other complex factors such as scenic content and the sound of turbulent water which contribute to preferences for water-proximal settings.

In the present study there were few significant correlations found among dependent measures. Stronger relationships between verbal and non-verbal indicators of stress recovery might have become apparent if different dependent measures were used. The cardiovascular indicators used here did not have strong relationships with the verbal measures, but this is not surprising given the variability of cardiovascular measures. Cacioppo and Tassinary (1990, p. 457) report that cardiovascular measures in psychophysiological measurement are not ideal for explaining behavior or responses to stimuli, although information about cardiovascular functioning may provide information about physiological events which are related to psychological occurrences. In order to understand observed psychophysiological responses, more complex events than laboratory treatments (e.g., past experiences and learned responses) must be considered. Negative ions do not appear to contribute to recovery from acutely stressful experiences as indicated by affective and cardiovascular measures of stress recovery. In naturally-occurring levels, negative ions may not produce any responses in the dependent measures studied here. Since rigorous procedures were followed for measuring and controlling levels of negative ions in the laboratory (e.g., calibration of measuring devices, grounding, repeated measurement of ions during the session, control of exposure time, natural fiber clothing), there is little reason to question whether exposure to the intended levels of ions was actually accomplished. Past studies have been criticized for failure to follow these procedures. Every attempt was made to ensure that known methodological shortcomings of past studies were accounted for. In outdoor conditions, primarily due to climatic changes, ions cannot be isolated as a treatment. The problem of not being able to control the weather remains an obstacle to studying the effects of naturally-generated ions.

According to the results of the present study, a person's stress level (induced by watching the film) effects a decrease in positive affect prior to a brief recreational engagement (watching the setting video immediately following the stressor). Depending on

the environment in which the recreational engagement occurs (natural or urban), even though the person's level of positive affect may continue to decrease, if he/she visits a natural setting the net drop in affect is likely to be less severe than if he/she were to visit an urban setting in the short time following the stressor onset. A person exposed to a natural setting ends up with a relatively better mental health state than a person exposed to an urban setting. Although a short period of time following the stressor onset may not be adequate for recovery and the person may have lower levels of positive affect than before the initial stressor onset, the person visiting a natural setting will end up relatively better off than the person who visited an urban setting.

Applied implications exist for natural resource management and urban planning decisions. Development of recreation facilities must be carefully planned to preserve natural features of a setting in order to provide optimal mental health benefits. In planning recreational settings in urban areas it may be important to retain as many natural features as possible. A reduction of the negative consequences associated with everyday stressful events and their subsequent costs to society would justify placement of a higher value on natural areas and their features. When decisionmakers are weighing the costs and benefits of developing areas for commercial or recreational use, advocates for preservation of natural areas and wildlands may have more credible arguments in ensuing political battles if they can show strong evidence for the benefits of leisure in natural settings. Preserving the natural features of certain areas within cities might help to reduce the negative consequences of stress. The proximity and availability of natural settings for people who live in urban areas may be useful for minimizing the negative consequences associated with exposure to acutely stressful siuations, which are encountered frequently in urban environments. Perhaps as a result of visiting a natural setting following a stressful experience, a person might be able to offset more of the negative feelings associated with the experience than if he or she had visited an urban setting, possibly reducing both recovery time and the magnitude of any related negative health consequences.

Conclusions and Recommendations

Negative air ions, at concentrations encountered in natural settings, do not have any effect on heart rate, pulse volume or mood. Naturally-occurring concentrations of negative

ions do not provide any immediate health benefits, but do not appear to be harmful. Natural areas as opposed to urban areas are more conducive to minimizing the negative consequences of acute stress, but negative air ions do not appear to be a restorative influence in these settings under the conditions studied here. Natural areas minimize the reduction in positive affect associated with exposure to stressful situations to a greater degree than urban settings. The use of natural areas for reduction in recovery time from short-term stress may be indicated by these findings, although no direct evidence for shorter recovery times was found here. The present results do not contradict previous findings of restorative effects of natural areas, and do expand our understanding of how natural areas may contribute to quality of life and the beneficial consequences associated with recreational engagements in natural settings. Implications exist for urban and natural resource planning and management decisions, where a higher value may be placed on natural features of sites if they are linked to improvements in mental health and subsequent benefits to society.

The present study raised questions which should be addressed in the future, which include establishing whether natural settings, by preventing reduction in feelings of well-being, contribute to a reduction in recovery time following stressful experiences. There is already evidence to support decreased recovery time from stress in natural settings as compared to urban settings. Although findings in the present study differed from past studies, they do not contradict findings of restorative benefits of natural settings, and in fact the present study's results provide both empirical support and a broader understanding of why people may find natural settings restorative. More research is also needed to identify the features of natural settings which contribute to these restorative effects. The connections between short-term and long-term consequences of restorative health effects associated with natural settings need to be established through longitudinal studies. Once these connections are empirically established and the magnitude of the associated benefits are quantified showing actual cost savings, much stronger arguments for preservation of the unique features of natural areas can be presented to decisionmakers in terms of overall benefits to society through improvements in health, well-being, and quality of life. Savings in mental health expenditures and reduction in social morbidity may be worth the loss of potential revenue from alternative decisions. Preserving opportunities for people to improve their mental

health and consequential improvements in the health and morale of the workforce due to fewer stress-related ailments and lower health care costs could contribute to increased national economic strength.

Future studies should also investigate the effects of longer exposure time to negative ions and possible interactions between levels and duration of exposure. Following longer exposure times (e.g., the amount of time spent fly fishing or on extended camping trips in close proximity to turbulent water), low levels of negative ions might contribute to improvements in physical and mental health states. The problem of controlling environmental variables prevents the use of true experimental designs in outdoor air ion studies, which is a major obstacle for studies attempting to investigate the effects of negative air ions as they are encountered in natural settings. For this reason, further investigations of the effects of negative ions will need to be confined to laboratory settings, or should implement designs that allow comparison of responses in indoor and outdoor treatment groups.

Since it would be difficult to simulate a "neutral" setting free of sensory stimuli, in order to further validate findings from studies where videotaped settings were used to simulate outdoor settings, more studies should be conducted to compare responses to both real and videotaped environments. There is a small amount of data available which validates the use of videos for this purpose, but it may be necessary to conduct further research of this nature to be more certain of the meaningfulness of the present findings. In order to maximize progress in research inquiries into benefits of leisure and theories of restorative environments, it will be necessary to pursue lines of investigation which can provide strong empirical results linking short- and long-term consequences of recreational engagements in natural settings to economic and social improvements at all levels of society. Continuing efforts to employ sound experimental design combined with revalidating and retracing our steps along the way will lend credibility to empirical findings and will expedite the process by which society recognizes, utilizes, and values the restorative benefits of leisure in outdoor settings.

REFERENCES

American Environmental Systems. (1987). Model Beckett Air Ion Counter and Mobility Discriminator. Boulder, CO: American Environmental Systems, Inc.

Baron, R.A. (1987a). Effects of negative ions on cognitive performance. Journal of Applied Psychology, 72, 131-137.

Baron, R.A., Russell, G.W., & Arms, R.L. (1985). Negative ions and behavior: Impacts on mood, memory, and aggression among Type A and Type B persons. Journal of Personality and Social Psychology, 48, 746-754.

Baron, R.A. (1987b). Effects of negative ions on interpersonal attraction: Evidence for intensification. Journal of Personality and Social Psychology, 52, 547-553.

Bradburn, N.M. (1969). The Structure of Psychological Well-Being. Chicago, IL: Aldine.

Brush, R.O. & Palmer, J.F. (1979). Measuring the impact of urbanization on scenic quality: Land use change in the northeast. In:Proceedings of Our National Landscape: A conference on applied techniques for analysis and management of the visual resource (pp.358-364). Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, USDA Forest Service General Technical Report PSW-35.

Brush, R.O. & Shafer, E.L. (1975). Application of a landscape preference model to land management. In: E.H. Zube, R.O. Brush & J.G.Fabos (Eds.), Landscape Assessment: Values,Perceptions, and Resources (pp.168-182). Strodsburg, PA: Dowden, Hutchinson & Ross.

Cacioppo, J.T. & Tassinary, L.G. (1990). Principles of psychophysiology: Physical,social, and inferential elements. New York: Cambridge University Press.

Campbell, J.M. (1983). Ambient stressors. Environment and Behavior, 15, 355-380.

Carlson, N.R. (1991). Physiology of Behavior. Boston, MA: Allyn & Bacon.

Charry, J.M. (1984). Biological effects of small air ions: A review of findings and methods. Environmental Research, 34, 351-89.

Charry, J.M. & Hawkinshire, F.B.W. (1976). Biologically mediated behavior in response to meteorolgical conditions. Unpublished paper, presented at the 84th Annual Convention of the American Psychological Association, September 7, 1976, Washington, DC.

Clark, R.N. & Downing, K.B. (1984). Why here and not there: The conditional nature of recreation choice. Proceedings-Symposium on Recreation Choice Behavior. General Technical Report INT-184. U.S. Dept. of Agriculture, Forest Service, Intermountain Research Station, 61-70.

Clark, L.A. & Watson, D. (1988). Mood and the mundane: Relations between daily life events and self-reported mood. Journal of Personality and Social Psychology, 54, 296-308.

ComAir Corporation. (1993). Owner's Manual: ComAir Electronic Air Purification Systems. Minneapolis, MN: ComAir Corp.

Coppom, R. (1978). Basic physics of atmospheric electricity and biologic effects. Unpublished Paper, Presented at Society for Clinical Ecology, Twelfth Advanced Seminar and Thirteenth Annual Meeting, November 18, 1978. Key Biscayne, FL.

Deleanu, M. & Stamatiu, C. (1985). Influence of aeroionotherapy on some psychiatric symptoms. International Journal of Biometeorology, 29, 91-96.

Dembroski, T.M. & Costa, P.T. (1987). Coronary-prone behavior:Components of the Type A pattern and hostility. Journal of Personality, 55, 211- 235.

Driver. B.L. (1992). Basic and applied research on the beneficial consequences of the provision and use of amenity goods and services. Notes for a presentation to the Recreation Management Staff, USDA Forest Service, Washington, DC, January 14, 1992.

Driver. B. L. & Cooksey, R.W. (1980). Preferred psychological outcomes of recreational fishing. In R.A. Barnhart & T.D. Roelofs (Eds.) Catch and release fishing as a management tool: A national sport fishing symposium. (pp. 27-40). Arcata, CA, Humboldt State University.

Driver, B.L. & Greene, P. (1977). Man's nature:Innate determinants of response to natural environments. In Children, Nature, and the Environment (pp. 63-70). U.S. Dept. of Agriculture General Technical Report NE-30.

Driver, B.L. & Knopf, R.C. (1976). Temporary escape: One product of sport fisheries management. Fisheries, 1, 24-29.

Driver, B.L. & Peterson, G.L. (1987). Benefits of outdoor recreation: An integrating overview. In A literature review- President's Commission on Americans Outdoors (pp. 1- 10). Washington, DC: U.S. Government Printing Office.

Dubos, R. (1976). Symbiosis between earth and humankind. Science, 193, 459-462.

Ekman, P., Levinson, R.W., & Friesen, W.V. (1983). Autonomic nervous system activity distinguishes among emotions. Science, 221, 1208-1210.

Frey, A.H. (1965). Experimental controls and biological experiments with atmospheric ions. Aerospace Medicine, 36,121-123.

Frijda: N.H. (1986). The emotions. Cambridge: Cambridge University Press.

Glass, D.C., & Singer, J.E. (1972). Urban stress: Experiments on noise and social stressors. New York, NY: Academic Press.

Godbey, G. (1991). Redefining public parks and recreation. Parks and Recreation, 26, 56-75.

Goléman, D.J. & Schwartz, G.E. (1976). Meditation as an intervention in stress reactivity. Journal of Consulting and Clinical Psychology, 44, 456-466.

Hartig, T., Mang, M. & Evans, G.W. (1991). Restorative effects of natural environment experiences. Environment and Behavior, 23, 3-26.

Hawkins, L.H. (1981). The influence of air ions, temperature, and humidity on subjective well-being and comfort. Journal of Environmental Psychology, 1, 279-92.

Hedge, A. & Eleftherakis, E. (1982). Air ionization: An evaluation of its physiological and psychological effects. Annals of Occupational Hygiene, 25, 409-19.

Herzog, T.R. (1985). A cognitive analysis of preference for waterscapes. Journal of Environmental Psychology, 5, 225-241.

Heywood, L.A. (1978). Perceived recreation experience and the relief of tension. Journal of Leisure Research, 10, 86-97.

Hull, R.B. (1991). Mood as a product of leisure: Causes and consequences. In B.L. Driver, P.J. Brown, & G.L. Peterson (Eds.) Benefits of Leisure (pp. 249-262). State College, PA, Venture Publishing.

Kaplan, R. & Kaplan, S. (1989). The Experience of Nature: A Psychological Perspective. Cambridge: Cambridge University Press.

Kroling, P. (1985). Naturally and artificially produced air ions-a biologically relevant climate factor? International Journal of Biometeorology, 29, 233-242.

Krueger, A.P., Andriese, P.S., & Kotaka, S. (1963). The biological mechanism of air ion action: the effect of CO2 in inhaled air on the blood level of 5-Hydroxytryptamine in

mice. International Journal of Biometeorology, 1, 3-16.

Krueger, A.P. & Reed, E.J. (1976). Biological impact of small air ions. Science, 193, 1209-13.

Krueger, A.P. & Sigel, S. (1978). Ions in the air. Human Nature, 7, 46-52.

Lazarus, R.S. (1966). Psychological stress and the coping process. McGraw-Hill, New York, NY.

Lazarus, R.S., & Cohen, J.B. (1977). Environmental stress. In I. Altman & J.F. Wohlwill (Eds.) Human Behavior and the Environment Vol. 3 (pp. 90-128). New York: Plenum.

Lazarus, R.S., Opton, E.M., Nomikos, M.S. & Rankin, N.O. (1965). The principle of short-circuiting of threat: Further evidence. Journal of Personality, 33, 622-635.

Lee, M. & Driver, B.L. (1992). Benefits-based management: A new paradigm for managing amenity resources. In:Proceedings, Second Canada/U.S. Workshop on Visitor Management in Parks, Forests and Protected Areas. Division of Natural Resources, University of Wisconsin. Madison, WI.

Lime, D.W. (1971). Factors influencing campground use in the Superior National Forest in Minnesota. Research Paper NC-60. USDA Forest Service North Central Forest Experiment Station, St. Paul, MN.

Lucas, R.C. (1964). Wilderness perception and use: The example of the Boundary Waters Canoe Area. Natural Resource Journal, 3, 384-411.

Maddi, S.R., Bartone, P.T., & Puccetti, M.C. (1987). Stressful events are indeed a factor in physical illness: A reply to Schroeder and Costa (1984). Journal of Personality and Social Psychology, 52, 833-843.

More, T.A. & Payne, B.R. (1978). Affective response to natural areas near cities. Journal of Leisure Research, 10, 7-12.

Nitzky, A. & Driver, B.L. (1994). Measurement of air ions in outdoor settings. Unpublished manuscript.

Nogrady, S.G. & Furnass, S.B. (1983). Ionizers in the management of bronchial asthma. Thorax, 38, 919-922.

Norusis, M. (1992). SPSS/PC+ Base Manual Version 5.0. Chicago, IL: SPSS,Inc.

O'Donnell, M.P. & Harris, J.S. (1994). Health Promotion in the Workplace. Albany, NY:

Delmar Publishers, Inc.

Olmsted, F.L. (1865). The value and care of parks. Report to the Congress of the State of California. [Reprinted in R. Nash (Ed.)1976. The American Environment. (pp. 18-24). Reading, MA: Addison-Wesley.]

Parrillo, J.E. & Fauci, A.S. (1979). Mechanisms of glucocorticoid action on immune processes. Annual Review of Pharmacology and Toxicology, 19, 179-201.

Reiter, R. (1985). Frequency distribution of positive and negative small ion concentrations, based on many years recordings at two mountain stations located at 740 and 1780 m ASL. International Journal of Biometeorology, 29, 223-31.

Rosenthal, T. & Ben-Hur, E. (1980). Superoxide involvement in negative ion effects. Nature, 288, 739.

Russell, J.A. (1980). A circumplex model of affect. Journal of Personality and Social Psychology, 39, 1161-1178.

Ryback, R.S. & Yaw, L. (1976). The magic of water. Man-Environment Systems, 6, 81-83.

Sauter, S.L., Murphy, L.R., & Harrell, J.J. (1990). Prevention of work-related psychological disorders. American Psychologist, 45, 255-268.

Sheets, V.L. & Manzer, C.D. (1991). Affect, cognition, and urban vegetation: Some effects of adding trees along city streets. Environment and Behavior, 23, 285-304.

Soyka, F. & Edmonds, A. (1977). The ion effect. New York: E.P.Dutton & Co.

Stainbrook, E. (1968). Human needs and the natural environment.In Man and Nature in the City. Proceedings of a symposium of the Bureau of Sport Fisheries and Wildlife (pp. 1-9). Washington,D.C., U.S. Department of the Interior.

Stone, A.A., Cox, D.S., Valdimarsdottir, H. (1987). Evidence that secretory IgA antibody is associated with daily mood. Journal of Personality and Social Psychology, 52, 988-993.

Thumann, A. (1992). Lighting efficiency applications. Lilburn, GA: The Fairmont Press.

Ulrich, R.S. (1981). Natural versus urban scenes: Some psychophysiological effects. Environment and Behavior, 13, 523-556.

Ulrich, R.S. (1983). Aesthetic and affective response to natural environment. In I.Altman & J.F. Wohlwill (Eds.), Human behavior and environment Vol. 6, Behavior and the natural environment(pp. 85-125). New York: Plenum.

Ulrich, R.S. (1988). Toward integrated valuations of amenity resources using nonverbal measures. In G.L. Peterson, B.L. Driver, & R. Gregory (Eds.) Amenity Resource Valuation: Integrating Economics with Other Disciplines (pp. 87-100). State College, PA: Venture Publishing.

Ulrich, R.S., Dimberg, U. & Driver, B.L. (1991). Psychophysiological indicators of leisure benefits. In B.L. Driver, P.J. Brown, & G.L. Peterson (Eds.) Benefits of Leisure (pp. 73-89). State College, PA: Venture Publishing.

Ulrich, R.S. & Simons, R.F. (1986). Recovery from stress during exposure to everyday outdoor environments. In J. Wineman, R. Barnes & C. Zimring (Eds.) Proceedings of the Seventeenth Annual Conference of the Environmental Design Research Association (pp. 115-22). Washington, D.C.

Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. Journal of Environmental Psychology, 11, 201-30.

Watson, D., Clark, L.A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. Journal of Personality and Social Psychology, 54, 1063-1070.

Watson, D. & Tellegen, A. (1985). Toward a consensual structure of mood. Psychological Bulletin, 98, 219-235.

Wohlwill, J.F. (1983). The concept of nature: A psychologist's view. In I. Altman & J.F. Wohlwill (Eds.) Behavior and the Natural Environment Vol. 6 (pp. 5-37). New York: Plenum.

Yates, A., Gray, F.B., Misiaszek, J.I. & Wolman, W. (1986). Air ions: Past problems and future directions. Environment International, 12, 99-108.

Yerkes, R.M. & Dodson, J.D. (1908). The relationship of strength of stimulus to rapidity of habit formation. Journal of Comparative Neurology and Psychology, 18, 459-482.

Zevon, M.A. & Tellegen, A. (1982). The structure of mood change: An idiographic/nomothetic analysis. Journal of Personality and Social Psychology, 43, 111-122.

Zube, E.H., Pitt, D.G., & Anderson, T.W. (1975). Perception and prediction of scenic resource values in the northeast. In: E.H. Zube, R.O. Brush & J.G. Fabos (Eds.) Landscape Assessment: Values, Perceptions, and Resources (pp. 151-167). Strodsburg, PA: Dowden, Hutchinson & Ross.

Zube, E.H., Vining, J., Law, C.S., & Bechtel, R.B. (1985). Perceived urban residential quality: A cross-cultural bimodal study. Environment and Behavior, 17, 327-350.

Zuckerman, M. (1977). Development of a situation-specific trait-state test for the prediction and measurement of affective responses. Journal of Consulting and Clinical Psychology, 45, 513-523.

TABLE 1.
NEGATIVE AIR ION CONCENTRATIONS
UNDER NATURAL OUTDOOR CONDITIONS[2]

Conditions	Ions/cm^3 of air
polluted city air	300
low pollution urban park or rural area	700-1000
rural or natural area, edge of a non-turbulent body of water (pond or lake)	700-1200
edge of a turbulent stream or river (whitewater)	1500-5000

[2]Data compiled from Hawkins, 1981, Nitzky & Driver, 1994, and Reiter, 1985.

TABLE 2.
DIFFERENCES IN POSITIVE AFFECT BETWEEN SETTING GROUPS
(N=94)

Setting	Adjusted Mean Change in Positive Affect*	F	p
Natural	-6.35	5.73	.019
Urban	-9.10		

*on a 50 point scale

TABLE 3.
CHANGES IN ITEM AND SCALE SCORES FROM PRE- TO POST-RECOVERY FOR NATURAL AND URBAN SETTINGS (N=94)

Item [PA/NA]	Mean change in score* natural/urban	F	p
interested [PA]	.45/1.06	8.362	.005
inspired [PA]	-.80/0	11.126	.001
determined [PA]	-.28/.31	8.73	.004
irritable [NA]	.76/0	13.408	<.001
jittery [NA]	1.39/.66	11.308	.001
Scale			
Positive Affect	1.76/4.54	4.977	.028
Negative Affect	9.15/6.35	3.962	.050

*Refer to text for explanation of scores. For individual items, a scale of 5 points. For entire scales, a scale of 50 points. Change scores indicate raw difference between stressor and recovery period PANAS scores. Differences are reported in this direction of change: stressor period score - recovery period score = change score.

TABLE 4.
OVERALL CHANGES IN POSITIVE AFFECT SCORES OVER DURATION OF EXPERIMENT FOR NATURAL AND URBAN SETTTING GROUPS*

	NATURAL	URBAN
Baseline to stressor (response to stressor)	4.59	4.61
Stressor to Recovery (recovery response)	1.76	4.54
Baseline to Recovery** (overall change)	6.35	9.15
Raw Score Post-Recovery***	22.1	19.7

*All numbers are shown as positive values reflecting magnitude of the *decrease* in positive affect scores. Actual values are negative.
**Significant ($p < .05$)
*** Actual mean recovery period scores. The values in this row are positive.